



Multi-Frequency Tuning Using Cascaded Mechanical Tuners

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50+ years of measurement confidence!

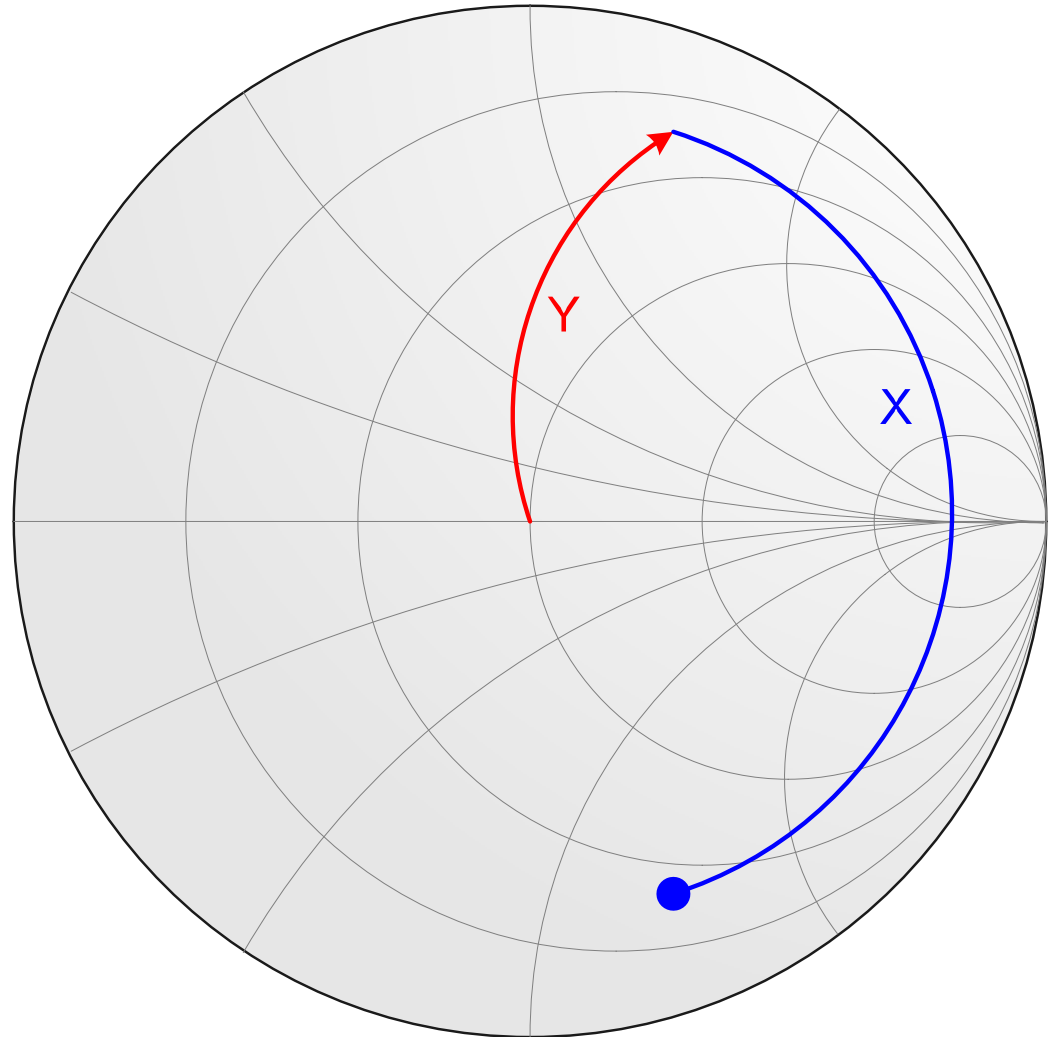
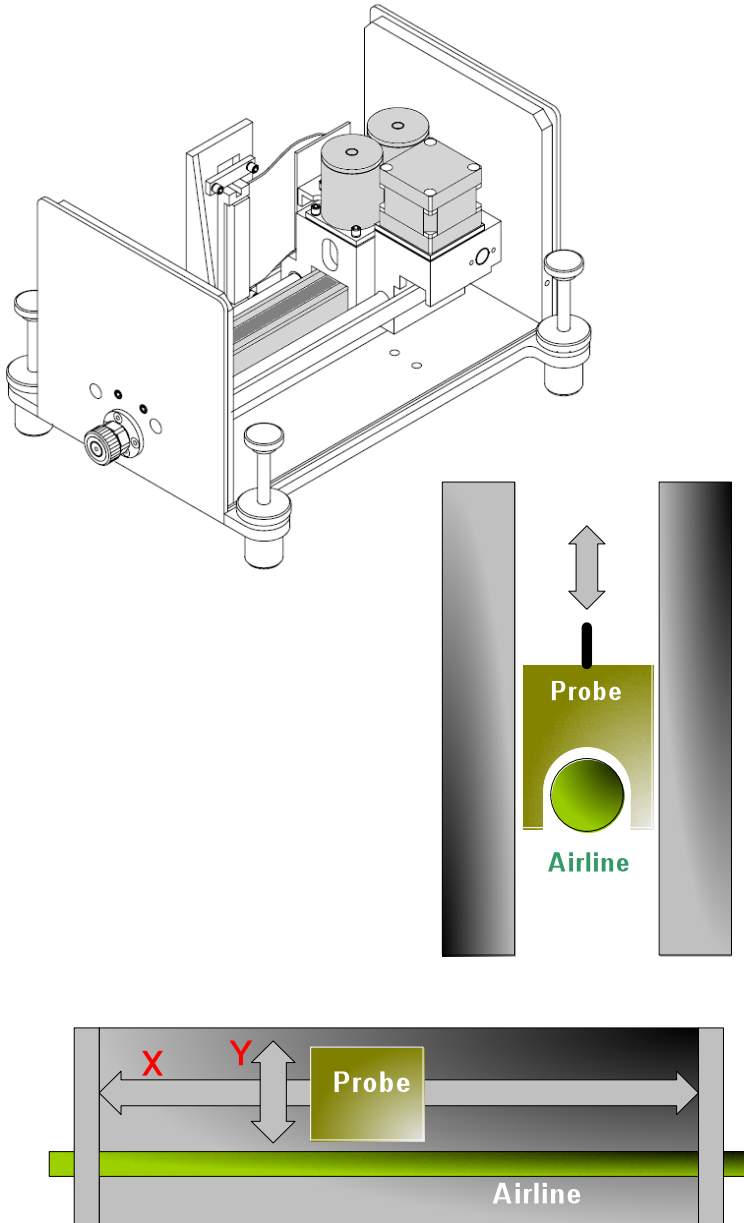


History of Harmonic Tuning

- Phase Adjustment only
 - Stubs inside test fixtures (Traditional approach)
 - FOCUS harmonic rejection tuners (late 90th)
- Magnitude & Phase Adjustment
 - Triplexer and tuners (early 90th)
 - ATN electronic tuners (mid 90th)
 - FOCUS MPT tuner (2004)
 - MAURY cascaded tuners (2008)

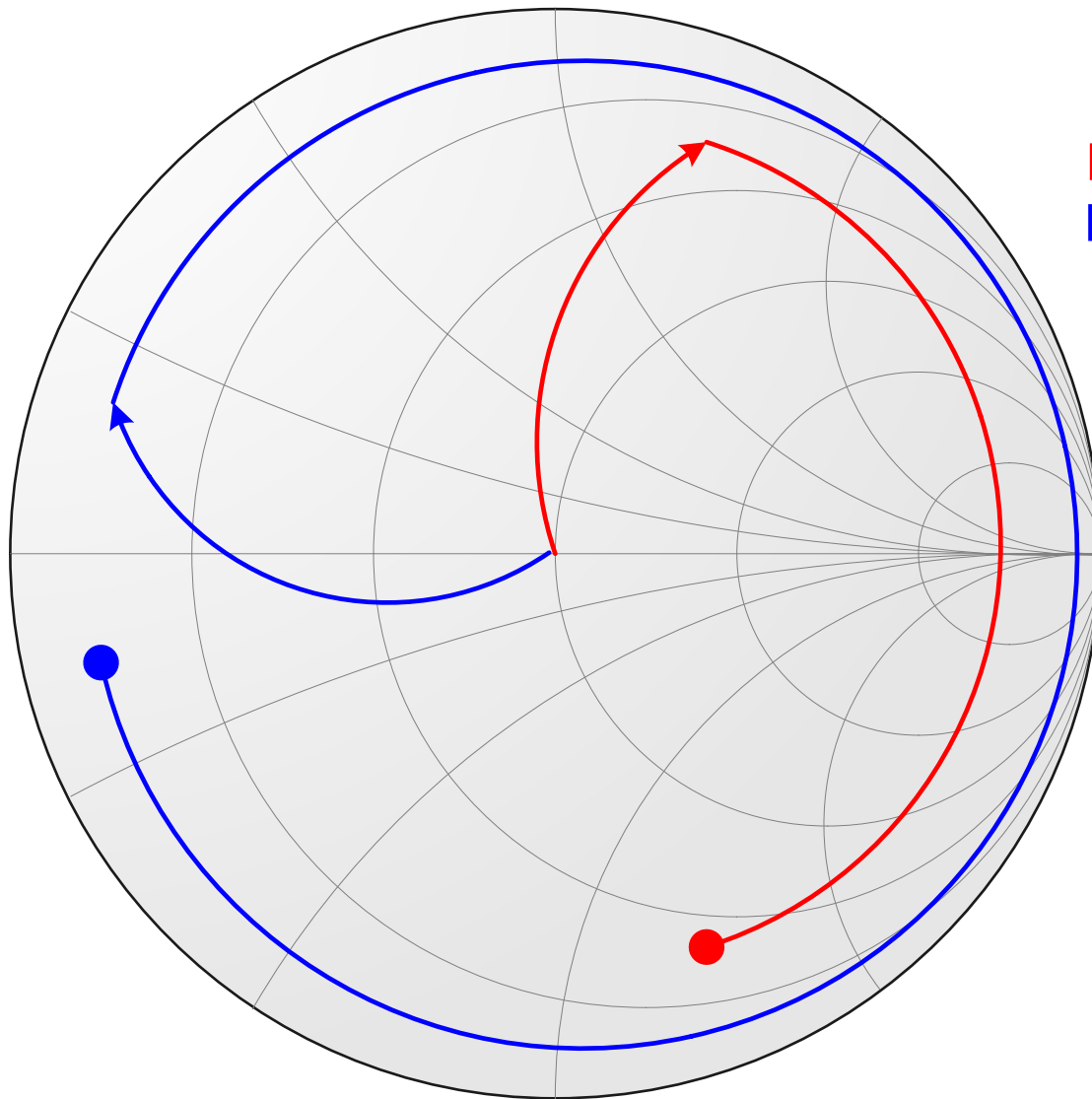


The *SLIDE-SCREW TUNER*



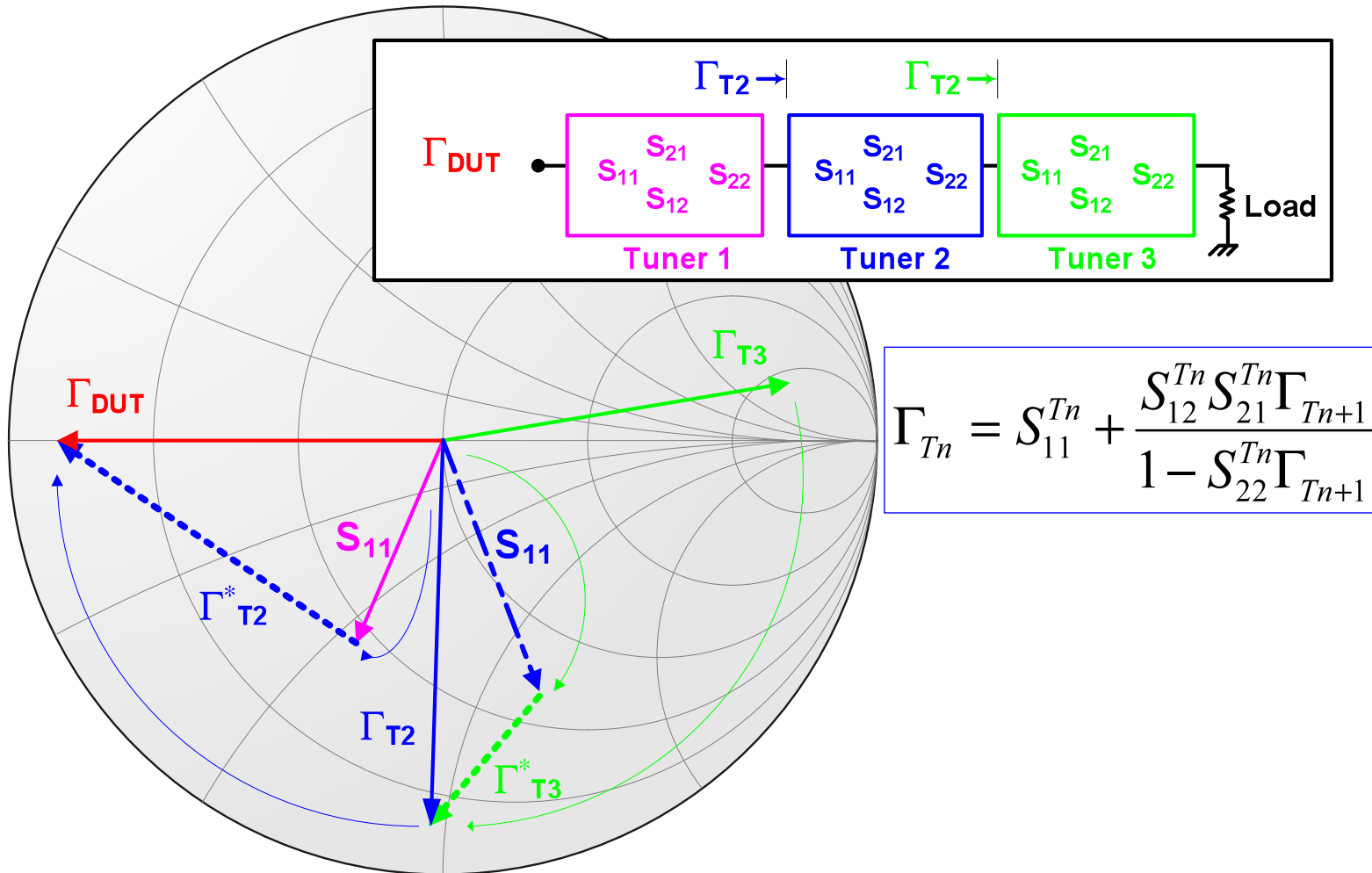


What happens at harmonic frequencies



Fundamental Frequency F_0
Harmonic Frequency $2 \times F_0$

Vector Cascading



$$\Gamma_{Tn} = S_{11}^{Tn} + \frac{S_{12}^{Tn} S_{21}^{Tn} \Gamma_{Tn+1}}{1 - S_{22}^{Tn} \Gamma_{Tn+1}}$$



Vector Cascading

S-Parameter Analyzer

S-Parameter of TUNER Gamma | 2nd Term

Tuner	Carriage	Probe	S-Parameters	Gamma 2nd Term
Tuner 1	10955	883	F1: 0.464/-121.0 0.877/-71.4 0.874/-71.4 0.463/158.4 F2: 0.627/-140.1 0.764/-131.1 0.762/-131.1 0.622/58.1 F3: 0.586/-154.3 0.786/172.9 0.784/172.9 0.584/-38.3	F1: 0.900/180.0 0.771/149.0 F2: 0.786/89.9 1.282/67.9 F3: 0.872/-88.5 0.829/-48.3
Tuner 2	13386	441	F1: 0.620/-74.8 0.769/-79.2 0.766/-79.2 0.618/96.5 F2: 0.767/-34.5 0.617/-135.1 0.615/-135.0 0.761/-55.3 F3: 0.732/10.4 0.646/173.6 0.643/173.7 0.724/157.7	F1: 0.913/-93.2 0.380/-124.4 F2: 0.957/-46.2 0.258/-83.2 F3: 0.930/-2.9 0.275/-40.7
Tuner 3	17779	167	F1: 0.804/11.8 0.574/-91.8 0.574/-91.7 0.796/-15.4 F2: 0.894/156.2 0.413/-140.4 0.413/-140.4 0.883/103.6 F3: 0.844/-56.0 0.477/171.9 0.477/171.9 0.834/-136.5	F1: 0.804/11.8 0.000/0.0 F2: 0.894/156.2 0.000/0.0 F3: 0.844/-56.0 0.000/0.0

S-Parameter and Loss (Fixture-Tuners-Back)

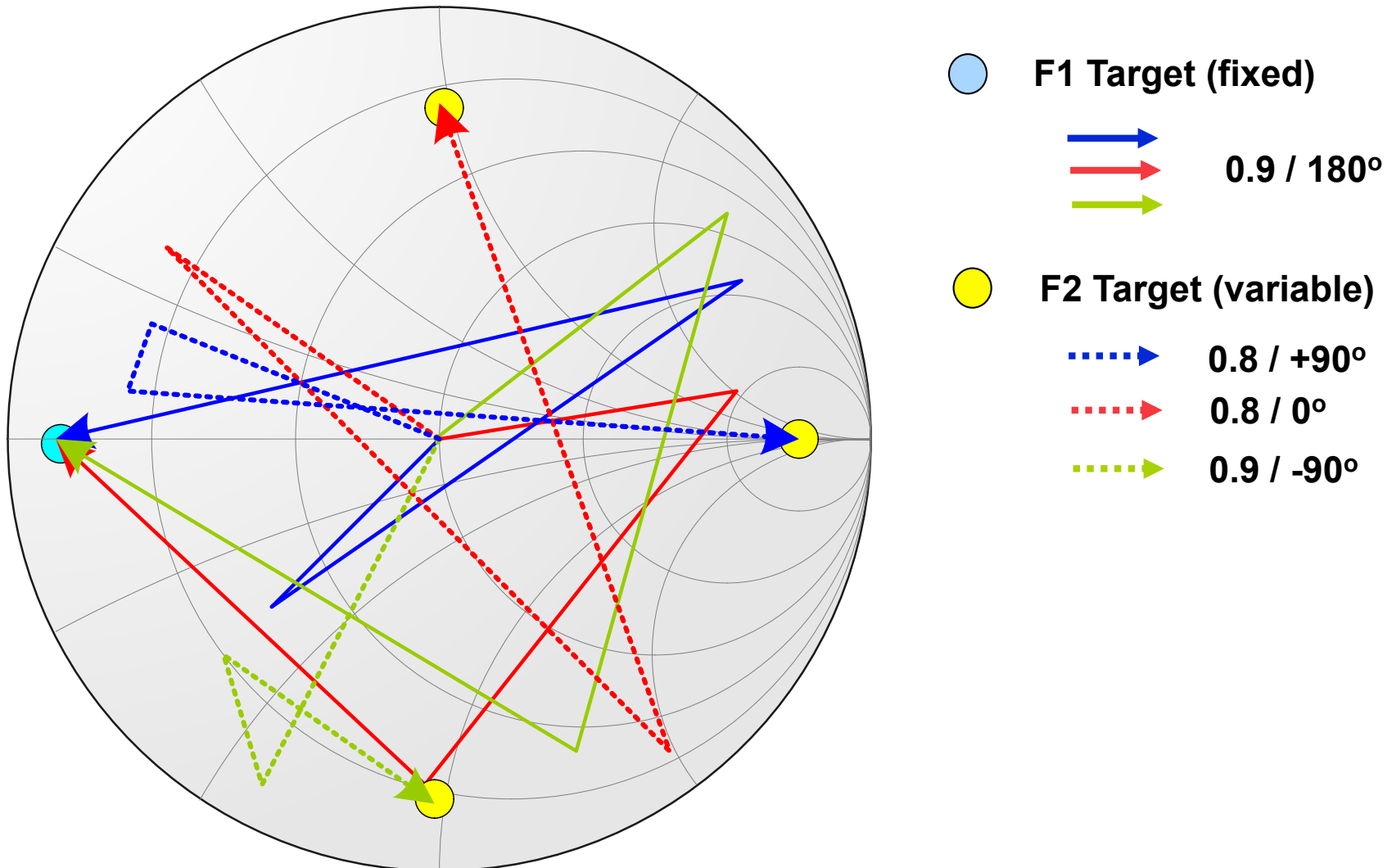
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1.00GHz 0.900/ 180.0 0.341/ 164.9 0.339/ 164.9 0.912/ -27.2 2.173dB
2.00GHz 0.786/ 89.9 0.341/ 0.5 0.340/ 0.6 0.902/ 97.6 5.212dB
3.00GHz 0.872/ -88.5 0.275/ 155.2 0.273/ 155.3 0.908/-140.0 5.052dB
    
```

Calculate



Harmonic Tuning with fixed F0 target





Tuner Characterization using Adaptive Modeling

Tuner Characterization - Interpolated Tuning Range Setup

Load Tuner

Instructions
Setup the reflection range variables.
Note: The Number of Controlled Harmonics is used to determine which tuner probe to use for each fundamental frequency.

Reflection Range setup

Point Separation Magnitude:

Maximum Phase step:

Minimum Probe Position:

Number of harmonics to Control:

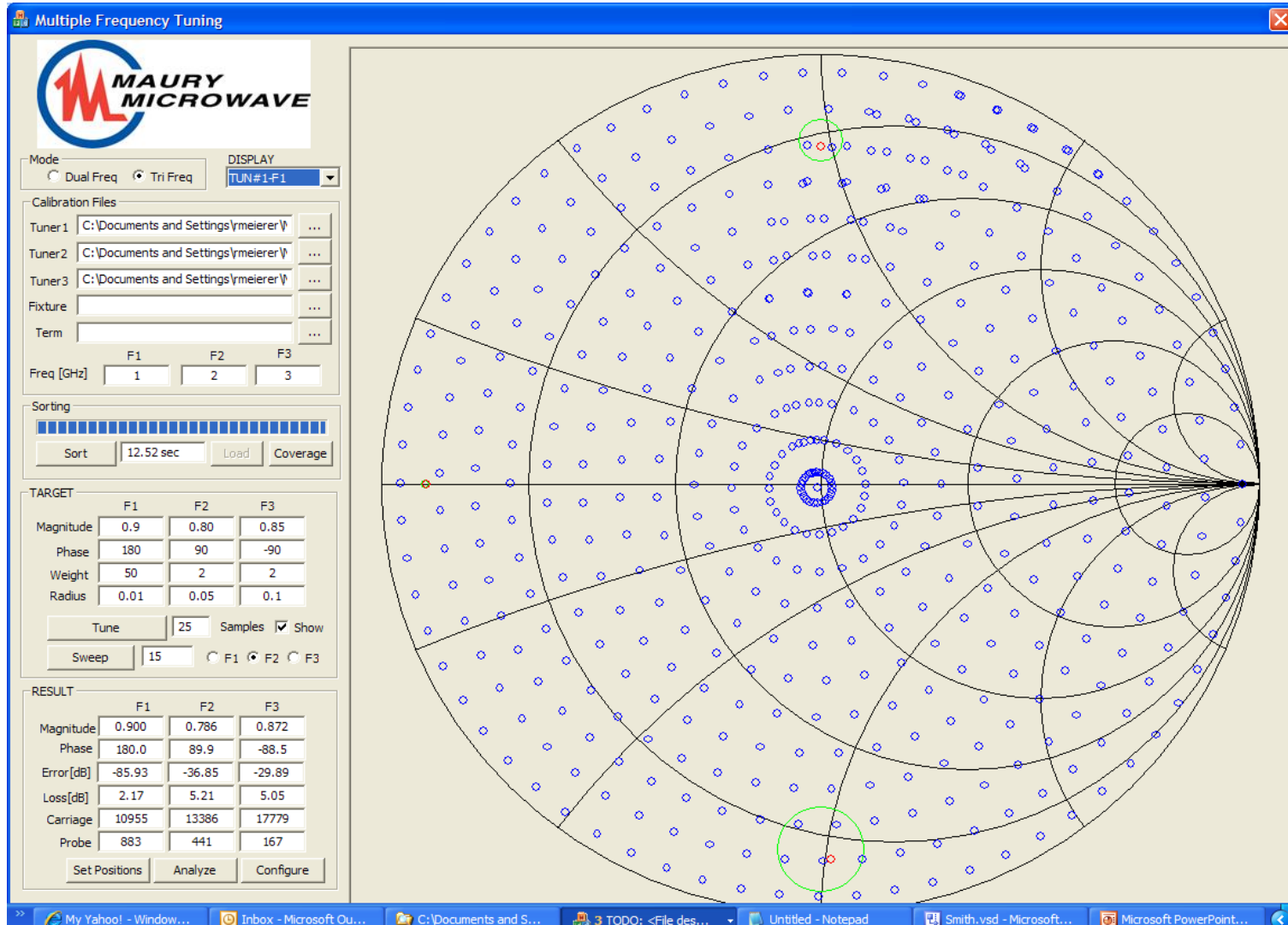
Maximum harmonics to Measure:

< Back Next > Cancel Help

- up to 3 controlled harmonics
- up to 10 harmonics to measure
- adjustable Point Separation
- maximum phase step
- automatically selects probe
- optimizes point distribution

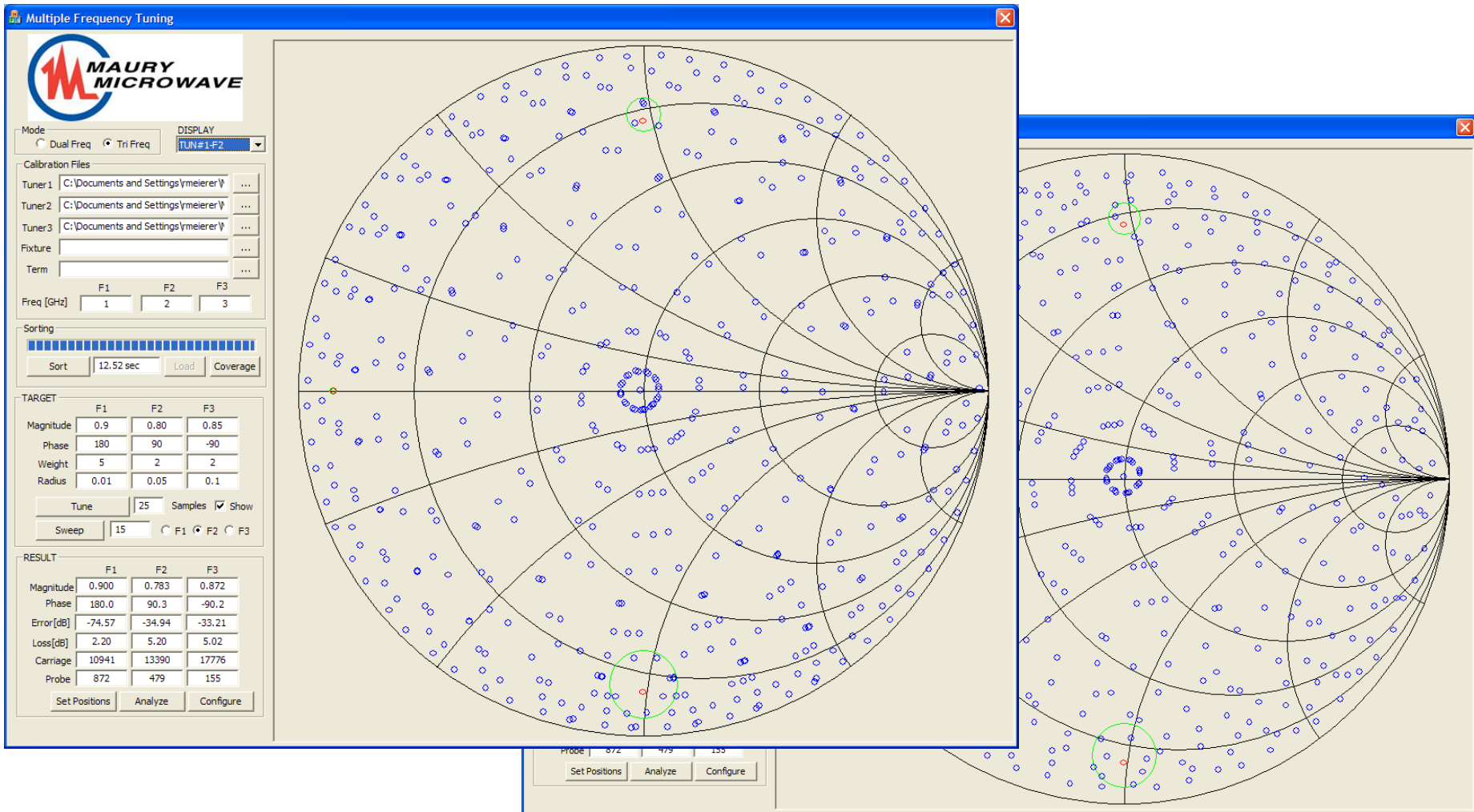


Tuner Characterization at PRIMARY Frequency





Tuner Characterization at SECONDARY Frequencies





Ultra fast in-memory Data Binning

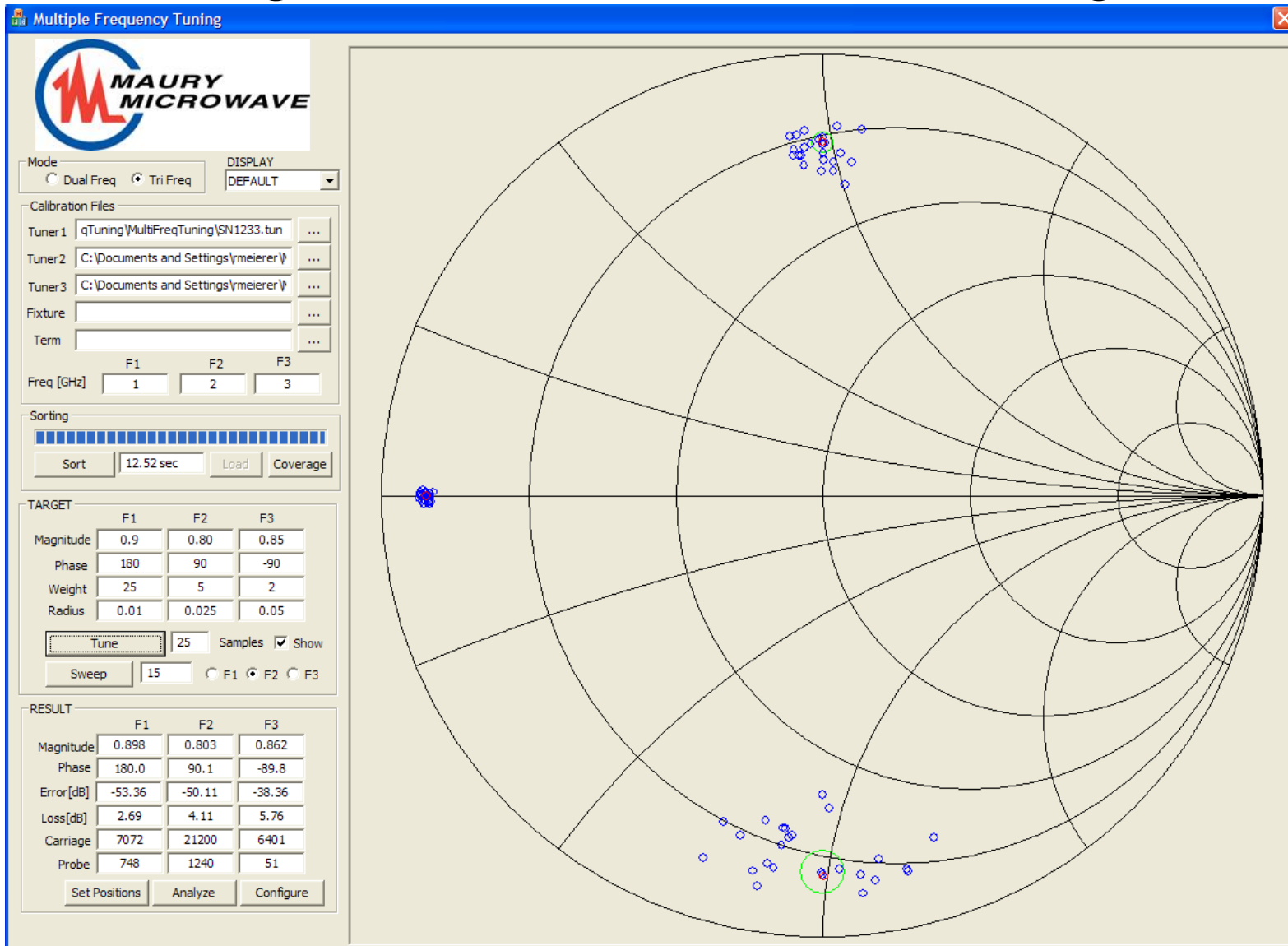
Points/Tuner	Combinations	Binning Time	Memory	Tuning
861	638 million	201 sec	2.3GB	2.1 sec
637	258 million	42.8 sec	1.05GB	1.8 sec
506	129 million	12.52 sec	532MB	1.2 sec
366	49 million	3.14 sec	219MB	0.6 sec

Benchmarks tests performed on Intel Core Duo T8300 @ 2.4GHz

Large Address aware application, 3GB of virtual address space

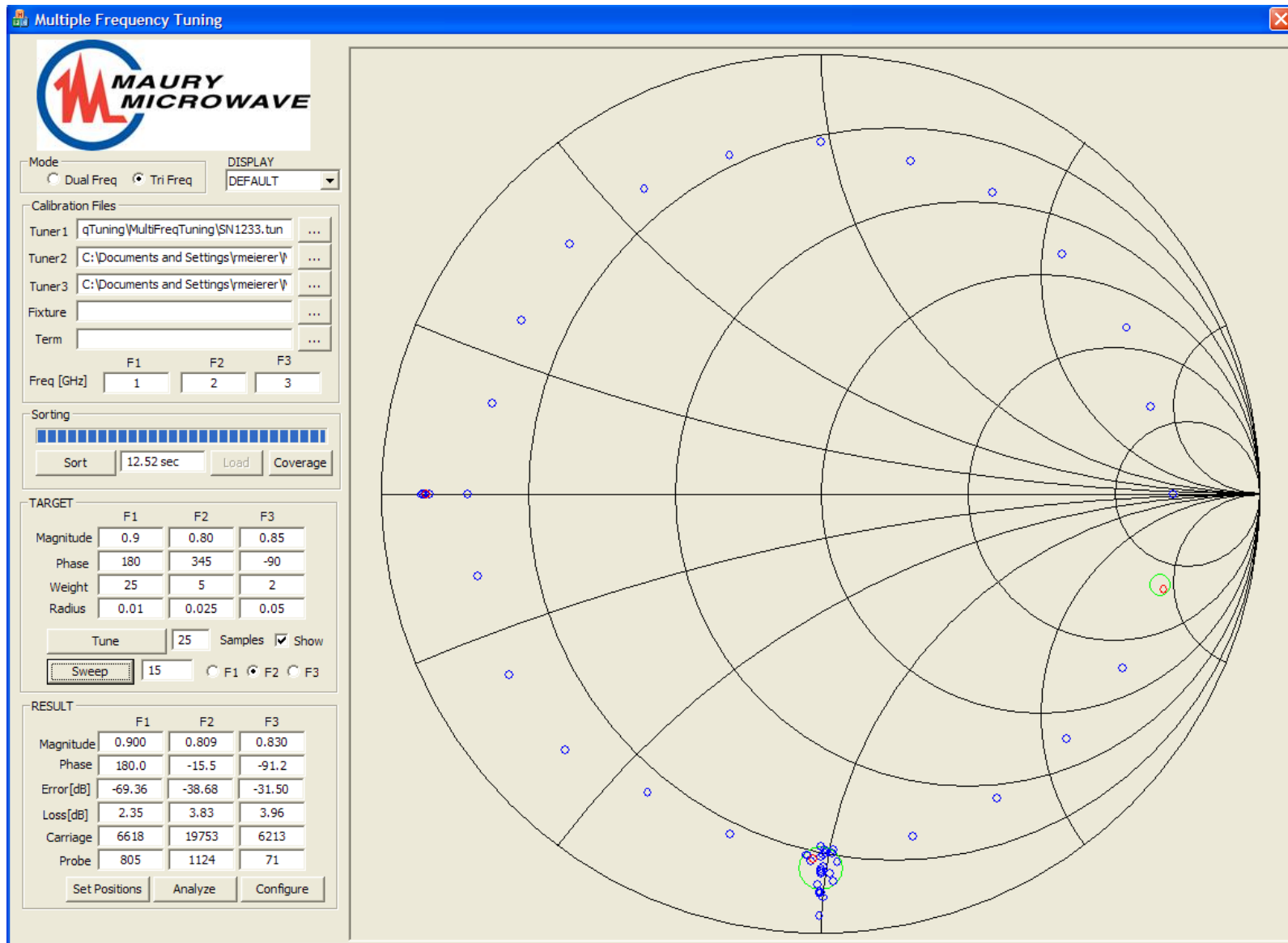


High Precision Harmonic Tuning





Harmonic Phase Sweep



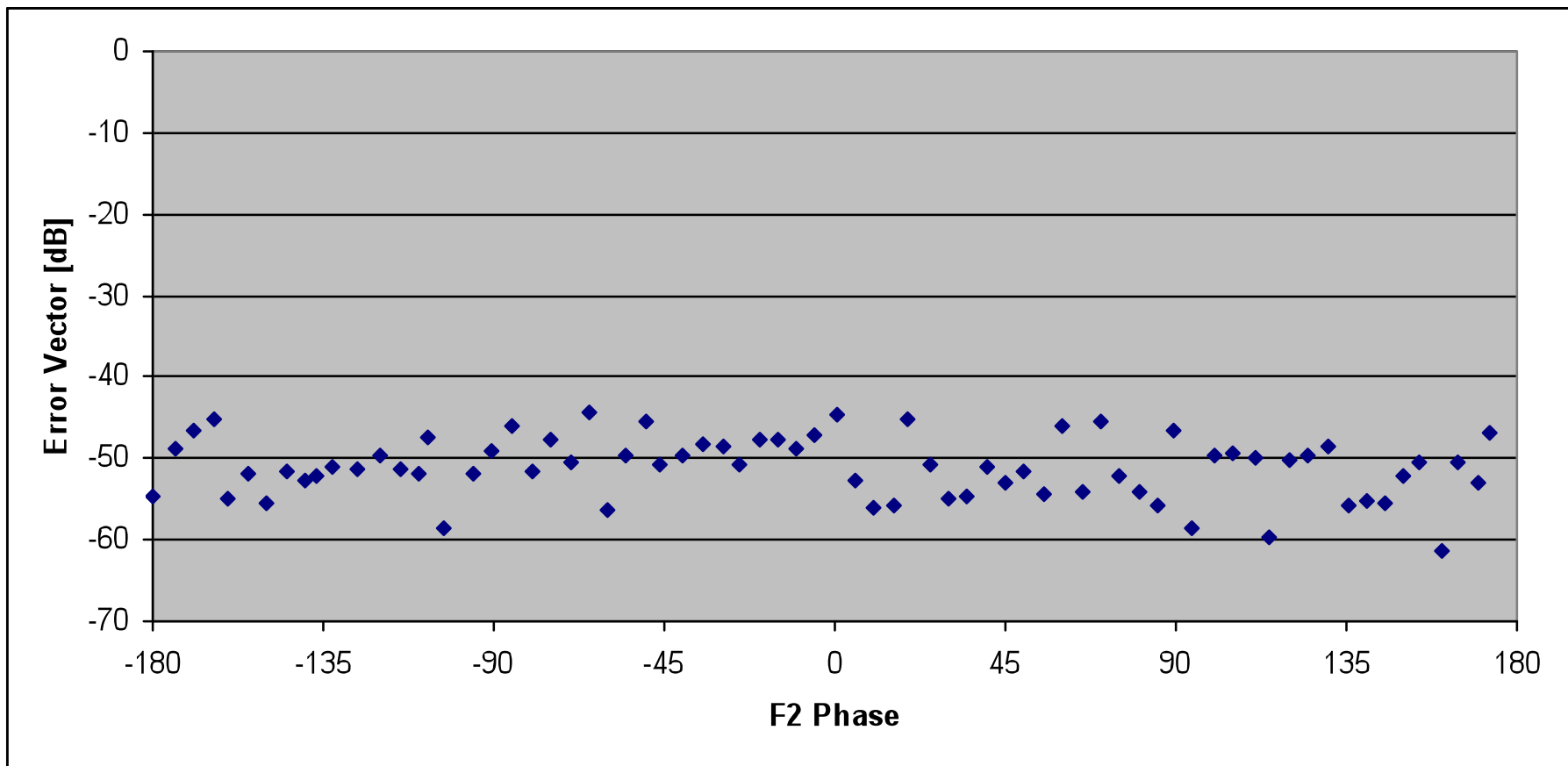


Measured Tuning Accuracy

F1: 2 GHz, fixed at 0.9 / 180°

F2: 4 GHz , sweep 0.8 / -180°..180°

F3: 6 GHz, fixed at 0.8/-90°





ATS Revision 5.2

Snpw - [C:\Program Files\Maury\ATS520\rmconf.cfg]

File Edit View Setup Calibrate Measurements Fixture Characterization Window Help TTest

VIEW SP FILE VIEW LP FILE VIEW PSWP FILE VIEW SRC TUNR VIEW LOAD TUNR INSTM OPTNS AND CNFIG FILES AND DIR CW CAL FILE CW

Power Block Diagram

Label: Demo mode setup with prematching tuners

MAURY MICROWAVE
ATS v5.20

For Help, press F1



Optimal Usage of Tuners

Example: you own 4 tuners

Configuration1: 2x Input – 2x Output 

Configuration2: 1x Input – 3x Output 

Configuration3: 2 separate setups with 2 tuners each




Conclusions

- **High Precision Harmonic tuning of 2 or 3 frequencies**
- **Tuning accuracy better than -45dB**
- **Ultra-fast in memory data binning**
- **Multi-loop fine tune algorithm**